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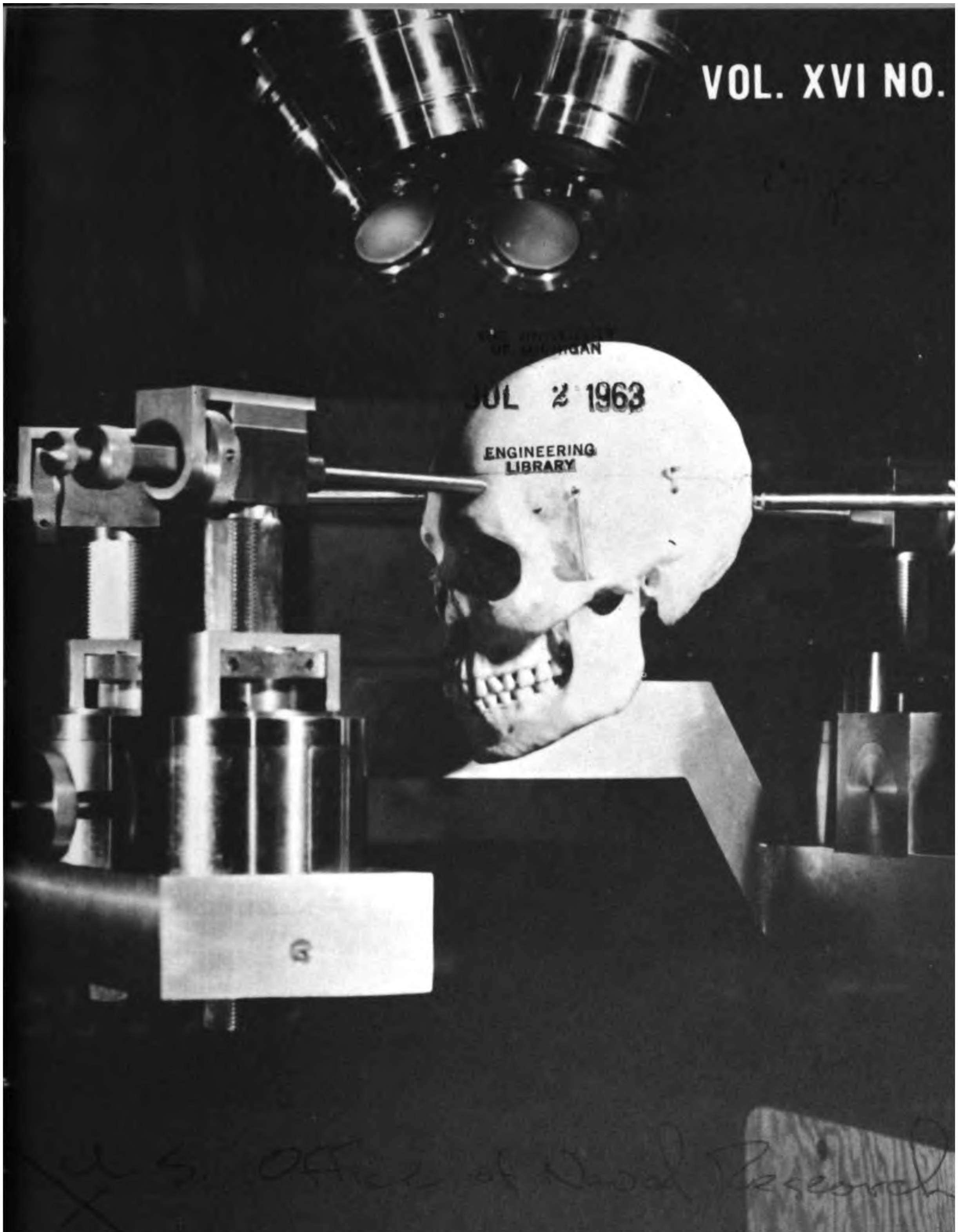

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NAVAL RESEARCH REVIEWS

JUNE 1963

DEPARTMENT OF THE NAVY · OFFICE OF NAVAL RESEARCH

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LCDR Alfred I. Weinstein celebrates his birthday with a cake made from shelter biscuits.

Surprise Session in a Fallout Shelter

One day last month, 34 reserve officers were led into the experimental underground fallout shelter at the National Navy Medical Center near Washington, D. C., ostensibly to hear a lecture. The talk was indeed given, but it proved to be only an introduction to the real purpose of the visit. The reservists were told that the Navy had not yet brought a group of men into the shelter and required them to live there for an unspecified length of time—without advising them of the experiment well in advance. Now it planned to do so.

It began dawning then on the reservists that they were the guinea pigs and that the test had, in fact, already started. The story is told on pages 27 and 28 and illustrated here and on the back cover (inside).

A card game helps to pass the time.

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Bioinstrumentation

New Aids in the Study of Man and Animal

Almost from the time of its inception in 1946, the Office of Naval Research has sponsored research studies designed to obtain basic data leading to the development of new tools for biologists. These studies, representing a comparatively new and specialized area of scientific endeavor called bioinstrumentation, are essentially joint activities of biologists and physical scientists and engineers. Results of the studies are expected to be of benefit not only to the Navy, but to human welfare in general.

Unfortunately, work in this field has lagged because of a deficiency in communications between the biologists, who need the instrumentation, and the engineers and physical scientists, who have the capacity to develop it. Few of the latter have had the background to interpret biological problems satisfactorily, and an equally small number of the former have known enough about mathematics, physics, and engineering to give the instrument designer much assistance.

Affected most acutely by this shortcoming have been the classical descriptive disciplines, such as systematics, ecology, animal behavior, biological orientation, and marine biology. On the other hand, the quantitative biological sciences (particularly biophysics and molecular biology) have benefited from some of the recent developments in electronics, solid state physics, and mathematics. Nevertheless, considerably more progress could be made in the latter fields, too, if suitable instruments were developed.

ONR's interest is not in improving, restyling, or competing with existing bioinstrumentation. Its efforts are focussed, rather, upon obtaining basic data for the development of new devices which can provide biological information never before available. Without this information, many of the significant advances made in recent years would not have been possible. By reviewing some of these advances, it is possible to get some idea of the nature of the achievements waiting to be made.

ARTIFICIAL LUNG

Many of today's lifesaving procedures have evolved because a surgeon with an idea consulted an engineer to put it into practice. In one case, the surgeon believed that, if he could circulate a patient's blood through an artificial lung for a short time, he could perform complicated surgery on the patient's real heart and lungs. He gave the specifications to an engineer, who produced a prototype for what are known today as extracorporeal circulators, or pump-oxygenators. ONR-supported research in this area resulted in the development of a simple, non-electric, portable pump-oxygenator now in use aboard ship.

ARTIFICIAL CORNEA

Another artificial organ was developed because an ONR-supported opthalmologist believed that he could restore sight to many military

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personnel who had been blinded following damage to the corneas of their eyes. Successful grafts had been made previously, but these operations were at best risky ones. After painstaking research, a group consisting of biologists, chemists, and engineers produced an intricate and precision-perfect artificial cornea from plastic. Prototypes of this new "tissue" were first tested successfully on rabbits and monkeys. The little pieces of plastic fitted and functioned so perfectly that they were then placed in the eyes of human volunteers—again with remarkable success. One fascinating feature of the artificial cornea is that it does not cause a foreign-body reaction. Important also is the fact that the substitute cornea is designed to be molded into the host's eye, which means that no sutures have to be taken.

BLOOD CELL COUNTER

Another valuable medical instrument developed cooperatively by biologists and engineers is the Coulter Blood Cell Counter. This device, which can make a rapid and accurate tabulation of various types of blood cells, was designed by Dr. Wallace H. Coulter, a former ONR contractor. In addition to completing its count regardless of the size or shape of the individual blood cells, the Coulter Counter operates about 100 times faster than a similar instrument formerly used by the great majority of hospitals and clinics. Dr. Coulter's instrument is used quite extensively, both in its original and modified forms, to diagnose such illnesses as anemia and leukemia. It has proved extremely valuable to the Navy as a field instrument.

ADVANCES IN CRYOBIOLOGY

Ever since blood transfusions were first made, biologists and physicians have been searching for a way to preserve human blood indefinitely. Until recently, however, they had made very little progress toward this goal.

In the belief that blood could be preserved by ultrarapid freezing, ONR supported a bioresearch group at the Linde Company Research Laboratory in Tonawanda, New York, to explore the feasibility of such a process. They found that at temperatures of 196 degrees below freezing blood can be preserved indefinitely.

Such combinations of cryogenic technology and biology have created a new area of biology. This new discipline, known as cryobiology, holds a vast potential for the eventual solution of problems, not only in biology and medicine generally, but also in such specialized sciences as space biology, or exobilogy.

One of the first pieces of hardware which evolved from a cryogenic research project is now being utilized in a neurosurgical procedure developed recently by Dr. Irving S. Cooper of New York City's St. Barnabas Hospital for Chronic Diseases. Dr. Cooper's "icy needle," or "cryogenic scalpel," performs almost bloodless surgery by inserting the bitter cold point of the tube into diseased tissue and freezing it to death without harming surrounding tissues. This technique has already been used to treat Parkinson's disease in more than 800 patients, as well as

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to remove eye cataracts and brain tumors. Again, the prototype of the cryogenic scalpel and subsequent improved models were developed for the medical profession by cryogenic engineers.

MAMMALIAN HAIR GUN

A new surgical technique for obliterating aneurysms of the brain was developed under ONR contract by Dr. John P. Gallagher at the Georgetown University Medical Center in Washington, D. C. Aneurysms are bubble-like deformities that appear in the walls of arteries at weakened points. In time, these bubbles or sacs begin to leak and eventually to rupture—with fatal results. The new procedures for dealing with them utilizes an air gun devised and built at the Naval Research Laboratory by Harrison P. Hagemeyer. This instrument propels a shaft of mammalian hair into the deformity, causing the blood in the interior to clot and permanently close the opening.

IMAGE INTENSIFIER

Many times, ONR bioinstrumentation studies result in the development of devices which become important outside of the biological field. One of these is the image intensifier, developed in 1947 under an ONR contract with Dr. Paul C. Hodges at the University of Chicago. This device employs the same principle now applied in the orthicon TV tube, which is used for commercial TV transmission as well as for military operations. The image intensifier has also been utilized in X-raying heavy metal sections and in radio astronomy studies.

Its original purpose, however, was to amplify electronically the fluoroscopic image of clinical disease entities. But other biological applications were soon found. For example, one of the original investigators applied the principles of the ONR study to the development of a high-speed X-ray camera for the Naval Air Development Center at Johnsville, Pa. Among other things, this camera has been used to observe the effects of gravitational forces on human and animal subjects in the huge Johnsville centrifuge. Much of the information it has provided is currently being used in the national space program.

GERMFREE ISOLATORS

Some of the most fascinating applications of new instrumentation in biological research are employed in the germfree animal studies which have been in progress for more than 30 years at the University of Notre Dame. The purpose of this work has been to develop the art of raising animals in germfree surroundings and then to use these individuals as research subjects. ONR began providing support for this work in 1946 in order to encourage the growing interest of several research groups in this new technique. To date, the germfree animals have been used to study tumor growth, mechanism of infections by viruses and other microorganisms, antibody development, immunity, resistance, nutrition, and aging processes. One of the devices developed under this study is the tissue culture isolator, which is now in use by a large number of research groups.

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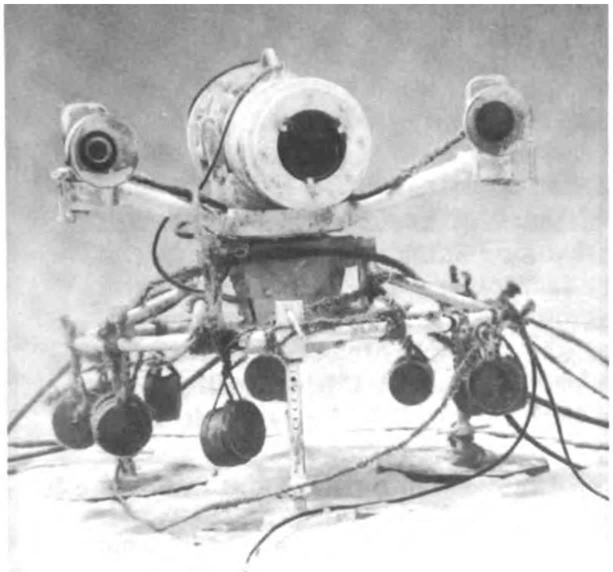

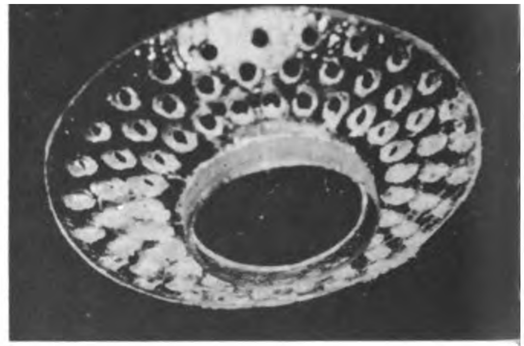

Above, artificial cornea before im-
plantation. Above right, the eye of
a rabbit in which the cornea has
been placed.

Above left, front view of TV camera set up on ocean bottom. Left, a large stingray approaches camera at depth of 35 feet.

The surgery underway in this plastic jacket isolator is exposed only to a sterile environment.

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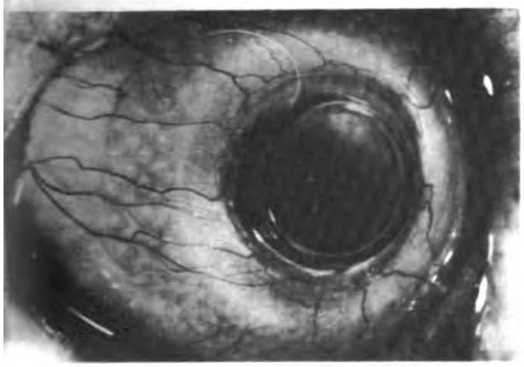
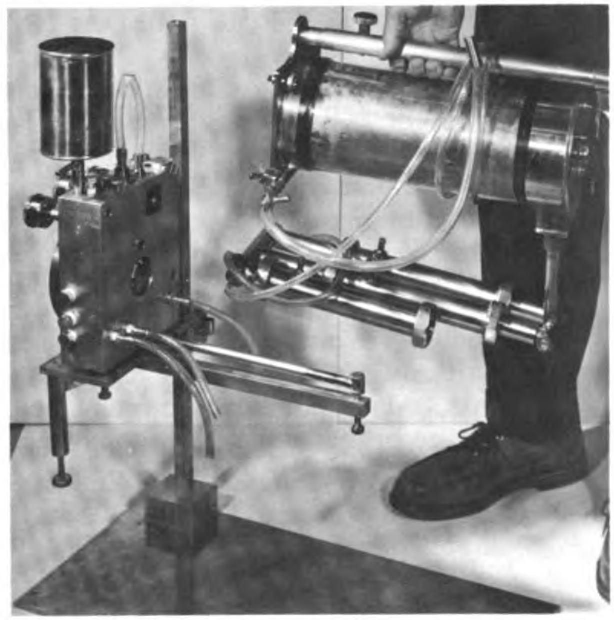
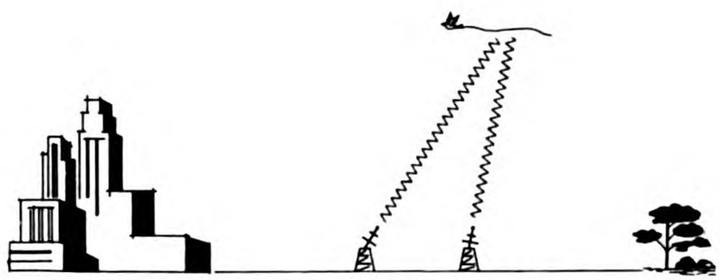




Artificial lung developed for use aboard ship. The pump is at left and the oxygenator at right.



Mammalian hair gun.

method of tracking birds flight is demonstrated by e drawing above and by this tuffed bird on which a te- metering device has been ounted.

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TELEMETERS FOR ANIMAL TRACKING

Although many of the instruments devised have been of benefit primarily to physiological and medical specialists, work has been progressing in other areas as well. For example, ONR has initiated a series of projects which have led to the design and development of specialized radio-tracking equipment. This equipment enables animal behaviorists and other related scientists to track the movements of unrestrained animals. After only three years of work, these studies have produced a family of radio telemetry prototypes capable of locating the positions of free-moving birds, terrestrial animals, and aquatic mammals. Also under development are sonic tracking devices to be used on marine organisms which do not swim at the surface and therefore cannot be tracked by radio telemetry.

Other equipment prototypes have been designed for the collection and study of marine plankton from intermediate and deep ocean waters, as well as for the collection of "aero-plankton" from high-speed, high altitude aircraft. Still other studies are aimed at developing prototypes of equipment and substances to attract marine animals so that they can be killed and eaten as emergency foods, or captured for study, or to repel those creatures which are dangerous to underwater swimmers, wreck survivors, rescue parties, and salvage workers.

UNDERWATER TV

One ONR program concerning the methods employed by marine animals to orient themselves and communicate with each other led to the installation of a unique underwater cable and television camera on the ocean floor in the Florida Straits. Because of the expense and complexity of this equipment, as well as the specialized mission for which it is intended, ONR has made the facility available for use by scientists from all over the world.

POWERFUL MICROSCOPES

In attempts to learn some of the secrets of life processes, scientists are examining the molecular structures of organic substances. Two of the most valuable instruments now in use in these investigations are the electron microscope and the ONR-developed color translating ultraviolet microscope. With a concerted effort, the biochemist, biologists, engineer and bionicist, working together, should eventually be able to explore this realm much more thoroughly.

TINY TRANSDUCERS

Future dividends are also foreseen in an ONR project through which an attempt is being made to produce transducers that will fit into the head of a catheter. Such devices would be able to measure directly the localized blood flow, blood velocities, blood pressures, and oxygen partial pressures at various points within the heart and the major blood vessels.

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ULTRASONIC RADIATION

In all of the sciences, the largest rewards of a research program are sometimes realized through by-products of the original effort. A good example of this is apparent in the work of Professor William Fry and his staff at the Urbana campus of the University of Illinois. When ONR began supporting Professor Fry's group more than 15 years ago, financial backing was provided for a relatively straightforward study concerning the effects of ultrasonic radiation on biological material. The information obtained was to be used to improve Navy sonar gear.

What was not foreseen at that time was that this study would expand into areas which would prove to be of considerable interest to other agencies. This program has included the treatment of Parkinson's disease and other harmful conditions. Today's staff—much larger than the original group—is working in a new laboratory building and utilizing a host of specialized electronic and mechanical instruments.

BETTER COMMUNICATION

Although ONR's specific mission is to sponsor basic research in the many fields of science that are important to the Navy, its policy is and always has been to cooperate with and assist other agencies and institutions working in related areas. In line with this policy, it is encouraging direct communication between biologists and physical and engineering scientists by sponsoring meetings intended to bring members of these disciplines together to exchange ideas on current problems.

One of these meetings held recently—the First International Biotelemetry Conference on Animal Behavior and Ecology—was an outstanding success in bringing the scientists and engineers together. It has identified a cadre of biologists with a language facility in physics, mathematics, and engineering. These people are already playing an important collective role in orienting engineers with respect to the most urgent problems in descriptive biology. In the process of performing this service, the group has developed a healthy respect for the motivation and integrity of the instrument makers. And it has also found that these specialists have been quite anxious to obtain guidance from biologists, in spite of the fact that they have previously had relatively few sources of reliable biological assistance. This new-found understanding has created an atmosphere of cooperation and has opened lines of communication which should prove invaluable in assuring the continued success of bioinstrumentation studies.

Two important awards were made last month to Navy scientists. The Naval Radiological Defense Laboratory, San Francisco, gave its second Annual Gold Medal for Scientific Achievement to Edward L. Hunt, an NRDL psychologist, on the basis of his demonstration that small doses of ionizing radiation stimulate the mammalian nervous system directly. The David Taylor Model Basin, near Washington, D. C., presented its coveted David W. Taylor Award for Scientific Achievement to Dr. H. M. Schauer, head of the Laboratory's Underwater Explosions Research Division, who contributed outstandingly to the improvement of ship bottoms and sides and the shock resistance of many ship components.

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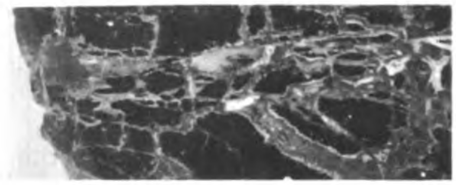
Glassy basalt recovered from rock layer about 575 feet below the ocean floor under 11,700 feet of water.



Mohole: A Resumé

Early in this century, the Yugoslav seismologist Andrija Mohorovicic (pronounced Moe-hoe-roe-veech-ik) observed that the seismic waves generated by the 1909 Croatian earthquake traveled through the earth at two speeds. Because the slower waves traveled at the speed expected if they were passing through the rocks of the earth's crust, Mohorovicic concluded that the faster waves had traveled through a layer of denser and more elastic underlying rocks. Thus was the lower limit of the earth's crust defined, and the mantle "discovered." The boundary is called "Mohorovicic Discontinuity," or "Moho."

The earth's crust, which overlies the Moho, ranges in thickness from about 2-1/2 to 45 miles, being thickest beneath the continents, particularly under the mountains, and thinnest beneath the oceans. The mantle extends about halfway to the earth's center, and comprises about 85 percent of the planet's volume.

At a meeting of the National Science Foundation's Advisory Panel for Earth Sciences in 1957, a provocative question was asked the scientists present: Of all the things it was possible for them to think of doing, which one would yield the most information about the earth? Professor (of geology) Harry Hess of Princeton University and Professor (of oceanography) Walter Munk of the University of California suggested drilling to the Moho. By doing so, they pointed out, information would be obtained that could lead to the answers to such questions as these: How old is the earth? What is the origin of the earth? How did life on earth begin? Why are the ocean basins fundamentally different from the continents? How old are the oceans and how did they become filled with water? Is the earth getting hotter or colder?

Later, Hess and Munk proposed the idea to fellow members of the American Miscellaneous Society, which gave its endorsement and established a committee to plan the study. This committee eventually became the AMSOC Committee of NAS-NRC—the group now concerned with the scientific aspects of drilling to the Moho. The direction and primary sponsorship of the project—called "Mohole"—was turned over to the National Science Foundation.

By late 1960, enough planning had been done to begin testing the idea at sea. The drilling barge CUSS I—a name derived from the original joint owners, the Continental, Union, Superior, and Shell Oil Companies—was modified for this purpose. Since its conversion was completed in the spring of 1961, test holes have been drilled into the ocean bottom off the coast of California near LaJolla, off the west coast of Mexico near Guadalupe Island, and from a site on the west coast of Puerto Rico.

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In the Guadalupe Island area the sediments that were pulled up contained fossil evidence of an extensive sea life that existed about 25 million years ago. Comparatively, that area today is an oceanic wasteland. Another determination made by means of the drilling was that sound waves penetrate the soft sediments at a slower rate than scientists had thought they did. If this low velocity applies to subsea sediments throughout the world, it could mean that they are thinner than had been supposed. Heat-flow measurements made in the Guadalupe holes provided another surprise. They revealed that the earth's internal temperatures are probably somewhat higher than they had been estimated to be previously; scientists are now pondering the variation between these measurements and theoretical calculations.

From the hole drilled on the west coast of Puerto Rico, a 1,000-foot core was obtained that consisted entirely of serpentine, a hydrated magnesium silicate that may once have been part of the underlying mantle that was altered by hydration and brought to the surface by folding and faulting. But the validity of this hypothesis probably will not be known until the Moho itself is reached by drilling.

When the hole will be drilled and where it will be located have not yet been decided. The current estimate is that about five years will be needed to cut through to the mantle—two or three years being required for further research and development, and two or three for the actual drilling. All that is known for sure about the site is that it will be where the ocean is 15,000 to 18,000 feet deep, and where the drill will have to pass through only about 15,000 to 18,000 feet of sediment and rock beneath the water.

Before this drilling can begin, a number of problems will have to be worked out. Among them, ways will have to be devised to get the drill back into the hole when the drill string is withdrawn for inspection or to replace a dull bit; reduce the forces exerted on the drill string by the ship's motion and other factors (one study of this problem appears on page 12 of this issue); hold the drilling vessel on station in deep water for two years or longer; produce special drilling fluids and circulate them between the ship and the bottom of the hole; develop suitable bits and pipe-handling, coring, and geophysical equipment. In addition, a drilling vessel—either new or converted—will be needed. Also to be considered is the large logistics problem of maintaining and supplying the ship many miles from land.

In 1959, the Office of Naval Research provided the major support for the first engineering study on Project Mohole. This study established the technical feasibility of drilling in very deep water (down to 18,000 feet) and of taking cores as much as 1,000 feet down from the ocean bottom. Since then, ONR and other Navy agencies have supported or carried out other phases of the project, such as the deep-ocean drilling near Guadalupe Island in the Pacific and the search for the final drilling site (NavResRev, Nov. 1962). One other of these Navy-Mohole tasks that are helping guide the project toward a successful conclusion is reported on pages 12 and 13.

A pictorial review of Mohole appears on pages 10 and 11.

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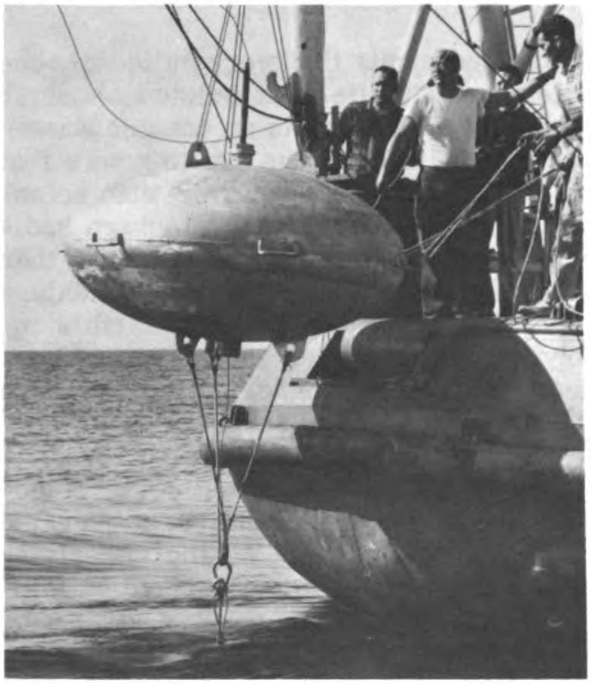
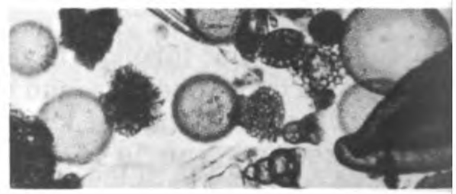


A deep-moored buoy used to help position drilling ship CUSS I is lowered into water off Guadalupe Island.

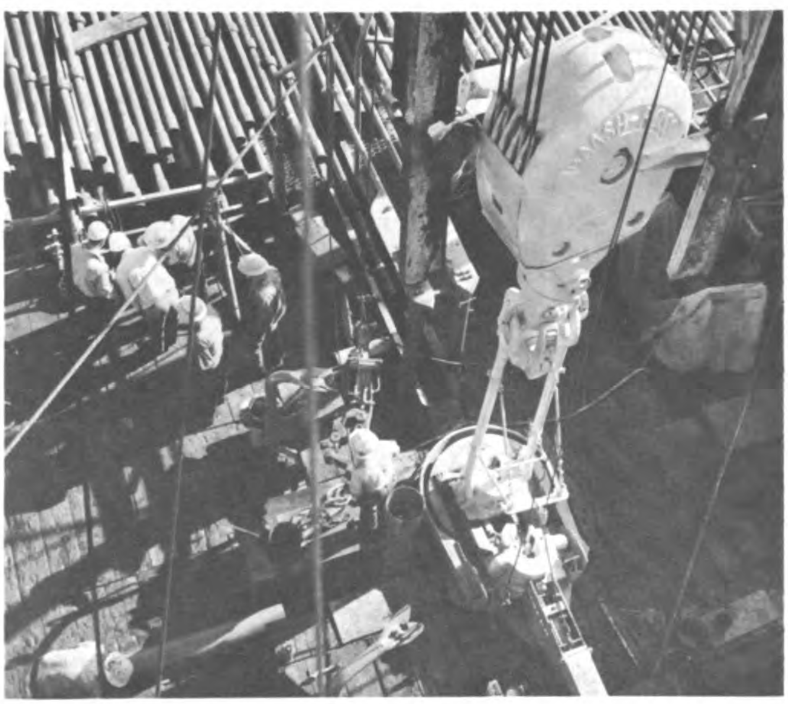
Mohole's Phase I in Pictures

Shown here is the ship CU I and some of the special equi ment used for Project Mohole experimental drilling activitie carried out in 1961. By mea of this equipment, holes we cut 1,035 feet into the earth crust beneath 3,111 feet of wat (off LaJolla, California) a through 600 feet of crust und 11,700 feet of water (off the we coast of Mexico near Guadalu Island).



Magnified remains of sea life c 20 million years ago taken fro core obtained near Guadalup Island.

Experimental Deep-Ocean Drilling



View of the drill ri floor of CUSS I, showing rotary table, some o the equipment for handling pipe, and lengths o drill pipe stacked i automatic racks. Th large traveling bloc lifts lengths of pipe an supports weight of entire drill string.

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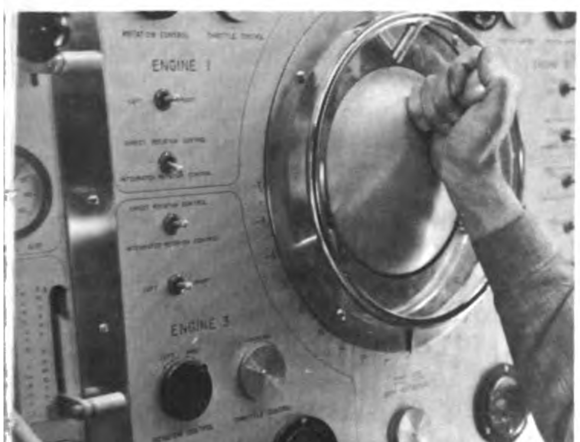
Bow of the drilling ship CUSS I, showing the 91-foot-high tower that supports drilling equipment. The ship was converted for Mohole's Phase I drilling.

Controls of the integrated steering system of CUSS I. The system permits the ship's four outboard engines to be operated simultaneously, regulating speed and direction of thrust, from a single "joystick" on console.



Workmen check giant guide shoe beneath hull of CUSS I. Shoe restricts bending of drill pipe at ocean surface.

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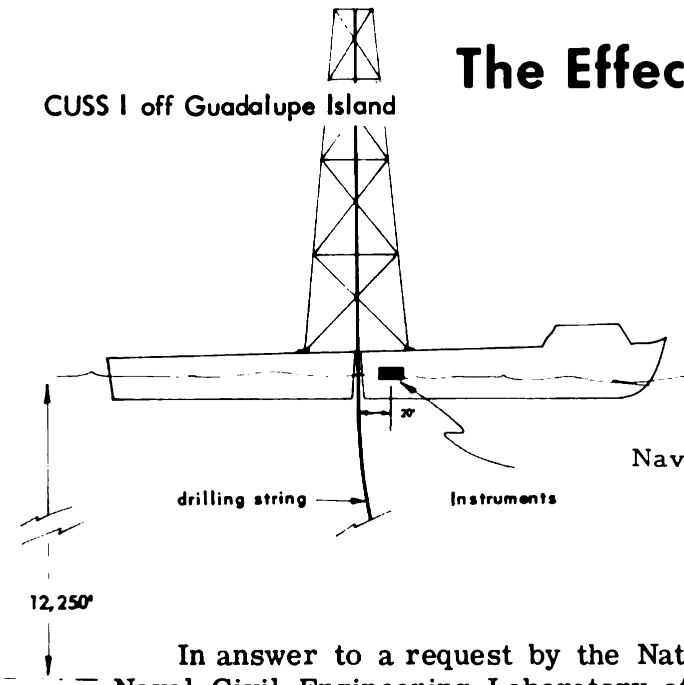

The Effects of Ship Motions on the Mohole Drilling String

Robert Easton
Naval Civil Engineering Laboratory

In answer to a request by the National Academy of Sciences, the Naval Civil Engineering Laboratory at Port Hueneme, California, undertook a study of the motions of a ship supporting the drilling string for the Project Mohole operation (see the preceding article). Specifically, NCEL was asked to determine whether or not the heaving motions of the vessel used for the experimental drilling for Project Mohole would generate vibrations in the drilling string suspended from the center of the ship. A second objective was to measure the ship's roll, which is an important consideration in the design of the guide shoe of the drilling string. The task was placed under the supervision of John T. O'Brien, director of NCEL's Harbor Division.

For the test, the ship CUSS I, which is owned and operated by the Global Marine Exploration Co. of Los Angeles, was to be used. It would assume a drifting attitude in deep water of the Pacific Ocean, where the wave period is about 3-1/2 seconds.

In order to determine what ship motions might significantly affect the operation of the drilling string, the NCEL investigators began the study with an analysis of the wave forces acting on the ship. A system of instruments was then devised that would be capable of sensing these motions—particularly heave—and of discriminating between them and other motions. This system included the following instruments, most of which were designed by task engineer J. J. Leendertse:

- A ship's motion transducer consisting of a very sensitive accelerometer mounted vertically.

- A pendulum-type roll indicator operating a linear potentiometer, the roll indicator having an extra-heavy pendulum which gave the system a long natural period (low frequency).

- A heave indicator, designed to sense both heave and pitch—the most unique device of the three. This instrument consisted essentially of two horizontally mounted torsional pendulums, which excited strain gage bridges whose electronic signals passed through a resonant amplifier.

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The completed system was installed as near the center of gravity of CUSS I as was feasible—in the mud storage room just forward of the drilling well. Two tests were then made as the ship was being towed at low speed in the Santa Barbara Channel off the coast of California in seas of states 2 and 3 on the Navy Oceanographic Office scale. During these tests, data were taken for a total time of about one hour.

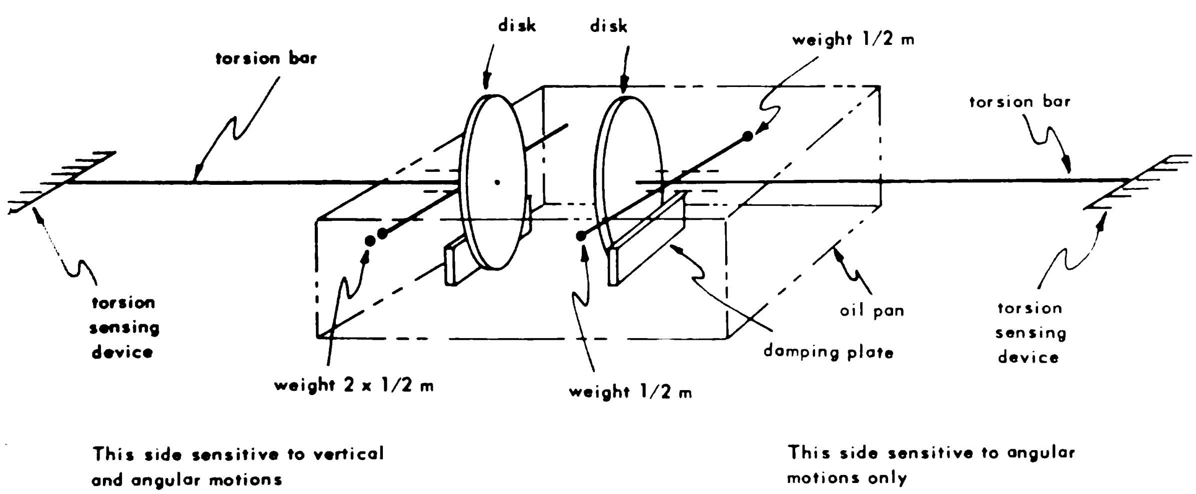
The wave and wind conditions encountered were estimated to be as follows:

- Dominant wave height: 2 to 3 feet.
- Wave oscillation: 1/3 to 1/5 cycle per second.
- Wind speed: 20 knots.

Under these conditions, the average amplitude in heave in the range of 1/3 to 1/4 vessel oscillations per second was found to be approximately 1/4 inch. The roll did not exceed three degrees.

The NCEL instrumentation system was used later aboard the CUSS I in the drilling of a number of test holes 1,050 feet deep off the coast of California in the vicinity of LaJolla. There the ocean is 3,100 feet deep. As in the earlier tests, the system served (1) to indicate trends toward extremes of roll and pitch far enough in advance to permit warning the drill platform that a motion of a certain magnitude could be expected; (2) indicate that under the conditions encountered off LaJolla the heaving of CUSS I apparently could not endanger the suspended drilling string; (3) indicate that the roll encountered need not affect the design of the guide shoe of the drilling string.

Following the LaJolla shakedown tests, CUSS I moved to the vicinity of Guadalupe Island off the coast of Baja California. There, at a water depth of 12,250 feet, four holes were drilled, the deepest to 600 feet. During these operations the heave indicator was used almost continuously and the other instruments on a stand-by basis. Again, the motions encountered did not endanger the drilling string.



Schematic drawing of NCEL heave indicator

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The Surprising Behavior of Pan and Wendy

Walter R. Miles
U. S. Naval Medical Research Laboratory

The intelligence and social behavior of apes have been the subjects of much investigation in the last 50 years through organized field studies and especially by experimentation and controlled observation of many animals confined in laboratory stations and zoological parks. Studies conducted on chimpanzees at the Anthropoid Station in Tenerife and the Yerkes Laboratories of Primate Biology in Florida, as examples, cover a wide spectrum of behavior. Working for food rewards, chimpanzees have amply demonstrated their excellent sensory and perceptual capacities, their abilities in learning, and in solving a variety of mechanical problems.

The social behavior of grooming by anthropoids remains a subject of theoretical scientific interest. Chimpanzees that are friendly often exhibit a mutual and excited desire to engage in grooming. Small wounds or sores found by the groomer may be given "treatment" by the lips, or a splinter in the skin may be removed by pinching the restricted area between the two forefingers. Such acts or behavior are not now thought to result from motives of "mutual aid." The groomer, or operator, seems to select the objectives and act on them for his own pleasure.

A cinder or grain of sand in the eye is a powerful stimulus demanding the attention of the sufferer. The behavior sequence reported here involved such an experience and a famous pair of chimpanzees named Pan and Wendy. It was not a planned experiment. It happened by chance at Orange Park in Florida on Sunday, February 21, 1954, when these chimpanzees were about 30 years old.

Professor Robert M. Yerkes had purchased Pan (male) and Wendy (female) from a ship's officer at a Boston dock in 1925. Their ages at that time were not known, but were estimated at two or three years. As adults, Pan was of medium size and weighed about 110 pounds; Wendy was smaller, weighing about 88 pounds. Describing the general behavior of these chimpanzees in 1943, Dr. Yerkes wrote, "Although they have long been acquainted as cage-mates, they have often disagreed about their relative social status. Each is extremely aggressive and determined, and neither hesitates to precipitate a fight. Usually, Pan assumes priority as his right, for he is that sort of personality. But if Wendy makes up her mind to have her way, she is so much more devastating in her attack that he almost invariably yields temporarily, in order to get along, peaceably and safely." At first, either of these chimps would struggle desperately if removed from the other one and taken to an experimental room. Several sessions were attempted before they became accustomed to the experimental outlook. Both learned to be good subjects and work well for food rewards on a variety of problems and in different laboratory enclosures. When Yerkes was writing about them in 1943 after 19 years of acquaintance, he refers to Pan's

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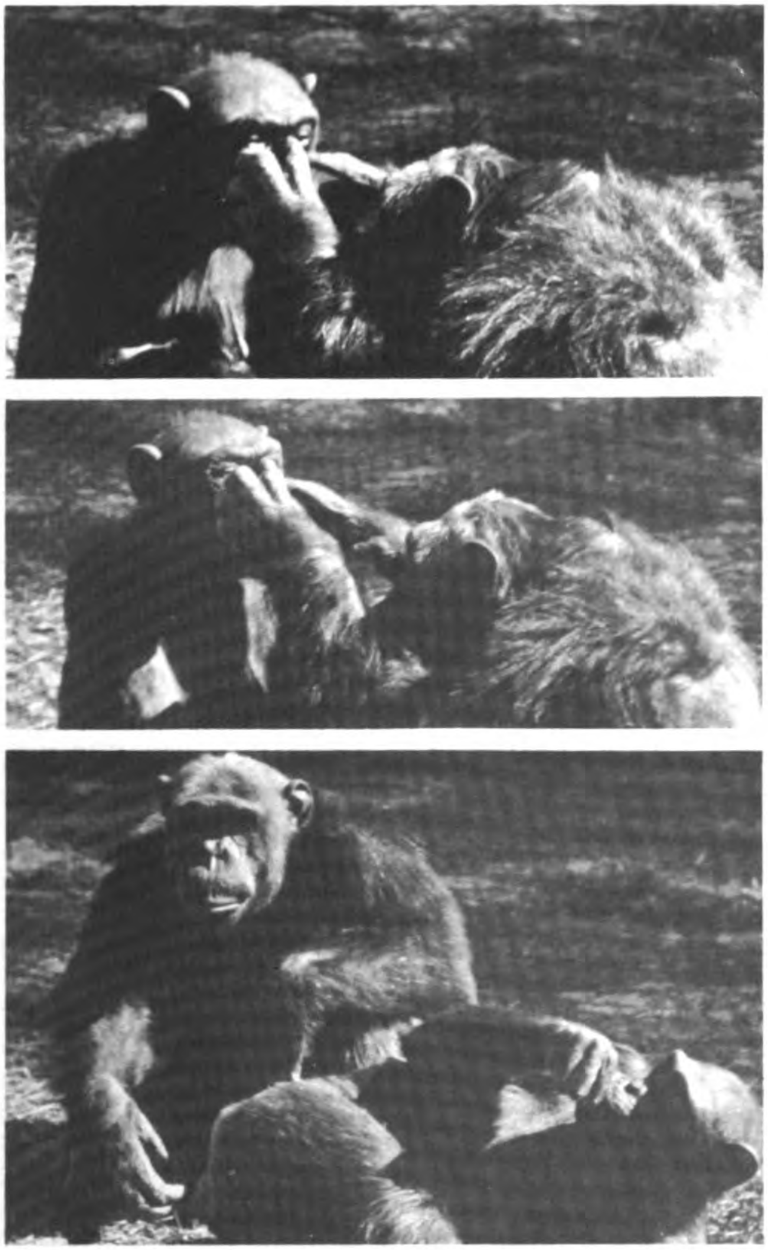
• *Adapted from a paper presented in April at the 100th Annual Meeting of the National Academy of Sciences in Washington, D. C.*



Pan carefully removes a cinder from Wendy's eye. Then the chimpanzees relax, Wendy enjoying the relief from pain, and Pan, perhaps, a sense of achievement.

history as a book of 60 typed pages, and to that of Wendy, the mother of seven valuable, good working offspring, as extending to 75 pages.

On that February morning in 1954, the writer and the late Dr. Henry W. Nissen, then Director of the Yerkes Laboratories, were

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standing about 15 feet from one side of the large outdoor enclosure which confined the chimpanzees. Pan was making his usual noisy, belligerent display for visitors--he was climbing the wire fence and pounding on the fence and the large strip of sheet metal at the top. He was jumping about, stamping, banging his hands together and shouting. From previous experience, we had learned to stand well back from the cage, knowing that Pan could throw sand with force and accuracy. In the midst of this excited behavior, Wendy came up behind Pan, whimpering. Pan suddenly turned, looked, and approached her. She sat down on the ground. He immediately crouched in front of her and with his two forefingers began manipulating her left eyelids.

This remarkable episode began with such a brief setting of the stage that it was far advanced before we could reach the side of the cage and thrust the lens of a camera, which fortunately we had brought with us, between the heavy fence wires to get a clear view. The first photograph taken, shows Pan crouching in front of Wendy looking into her left eye. He uses both of his hands for searching. With his left hand he appears to stabilize Wendy's head. With his right forefinger he draws down the lower eyelid, exposing the pink mucous membrane. Wendy's head is tipped toward Pan, who is viewing her eye from a distance of about five or six inches. The second photograph was taken a brief interval after the first one. Now the search is just about to conclude. Wendy has drawn her head back somewhat. Pan still retains about the same stance, but his right hand reaches out further as if to touch Wendy's left cheek. We can see the small thumb of Pan's right hand. The focal distance between Pan's eyes and Wendy's left eye has increased.

The moment Pan withdrew his fingers from Wendy's face signaling success of his attempt occurred with such suddenness it was not captured by a photograph.

As Wendy experienced relief, she lay down, resting her head on some straw, and letting her right arm lie limply on her body. Pan seated himself just behind her, his left leg flexed and his right forearm propped on his knee. He was quite relaxed. Curiously, his attitude toward his human observers seemed to have changed. He was not threatening now.

Pan stayed in the position shown in the third photograph for about five minutes. Just as that final photograph was taken, Wendy lifted her head to look at Pan. Is he plotting some mischief, or is he quietly enjoying a sense of achievement? There is no clear answer. Pan could have used his act of mercy as the prelude for an enjoyable period of grooming. Wendy could have withdrawn immediately after experiencing relief. Their remaining in physical contact in such passive states for several minutes after the pain in Wendy's eye had been relieved would seem to emphasize the psychological significance of the behavioral event. It was distinctly different from grooming. It was something special.

Man frequently gives succor to his fellow man, and since the early days of his history he has probably realized the value of doing so. He is not unique in these respects, however. His "cousins" from the treetops know something about such behavior and its impact, too.

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Shoreline Changes at Cape Hatteras:

An Aerial Photographic Study of a 17-Year Period

William D. Athearn
Claude Ronne
Woods Hole Oceanographic Institution

Some topographic features along the east coast of the United States change constantly in shape and position. In the space of only a few years, the tip of a cape may swing 90 degrees in direction and an inlet may move a considerable distance up or down the coast. So many changes are taking place, in fact, that if one were to photograph the coast periodically from the air, and then string these pictures together so as to accelerate the motion in the scenes, he would view a strip of land that literally rippled and fluttered like a banner.

Interest in the use of aerial photography as a rapid method of recording coastline changes prompted investigators at the Woods Hole Oceanographic Institution, with support from the Office of Naval Research, to make a series of photographic flights along the east coast. Since 1954 we have made 11 major air trips, most of them between Long Island, N. Y., and Charleston, S. C. At one time or another, however, we have covered the entire coast between Eastport, Maine, and the Rio Grande. In general, our group has made its observations by means of continuous low-oblique color photography. (The technique is described in (Naval) Research Reviews, April 1957.) But within the last two years, when conditions have permitted, we have taken higher altitude vertical photographs, particularly of features whose changes were expected to be most pronounced.

After comparing some of the photographs taken during the coastal flights, a number of interesting movements were observed, especially at Cape Hatteras and Hatteras Inlet, N. C. Because our vertical photographs proved very useful for measuring these movements, we obtained earlier "verticals," dating from 1945, from the U. S. Coast and Geodetic Survey. We were therefore able to make measurements of changes which had occurred over a 17 year period. Baselines were established between prominent points visible on each of the photographs, and their lengths were marked off on topographic maps (U.S. Geological Survey 7-1/2-minute quadrangle series, edition of 1950) to establish a scale of measurement for each photograph.

Cape Hatteras (Figures 1 and 2) is situated on the Outer Banks of North Carolina at the point where the trend of the coastline changes approximately 60 degrees—from north-south to northeast-southwest. The change in trend of the beaches immediately adjacent to the tip of the cape—the area covered in the photographs—is even more abrupt, amounting to about 90 degrees. It would seem probable, therefore, that natural changes occurring along these beaches should be quite dissimilar, inasmuch as the angle of incidence of wind and waves would be radically

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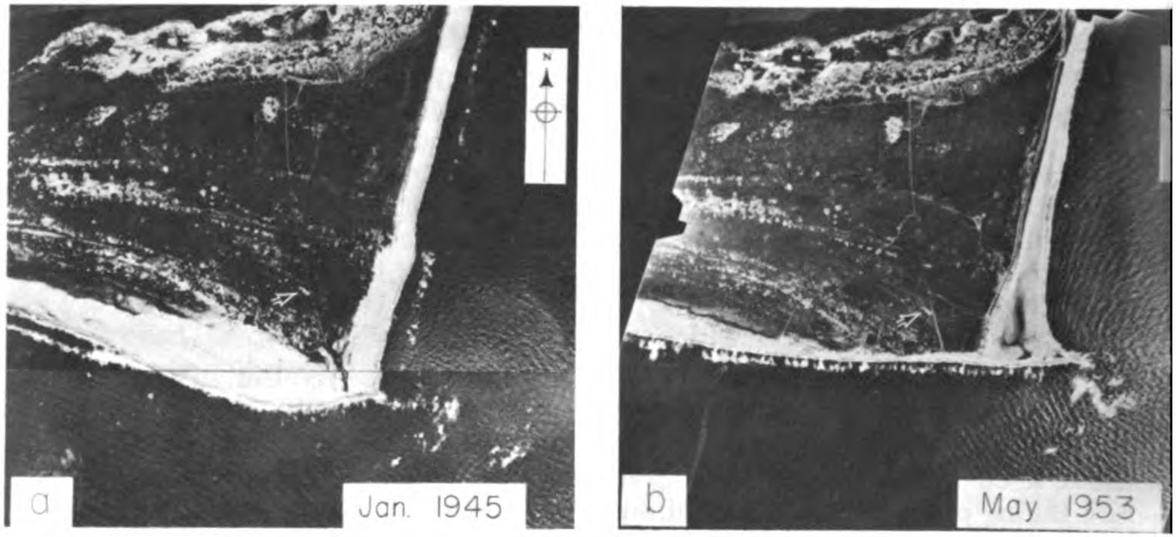
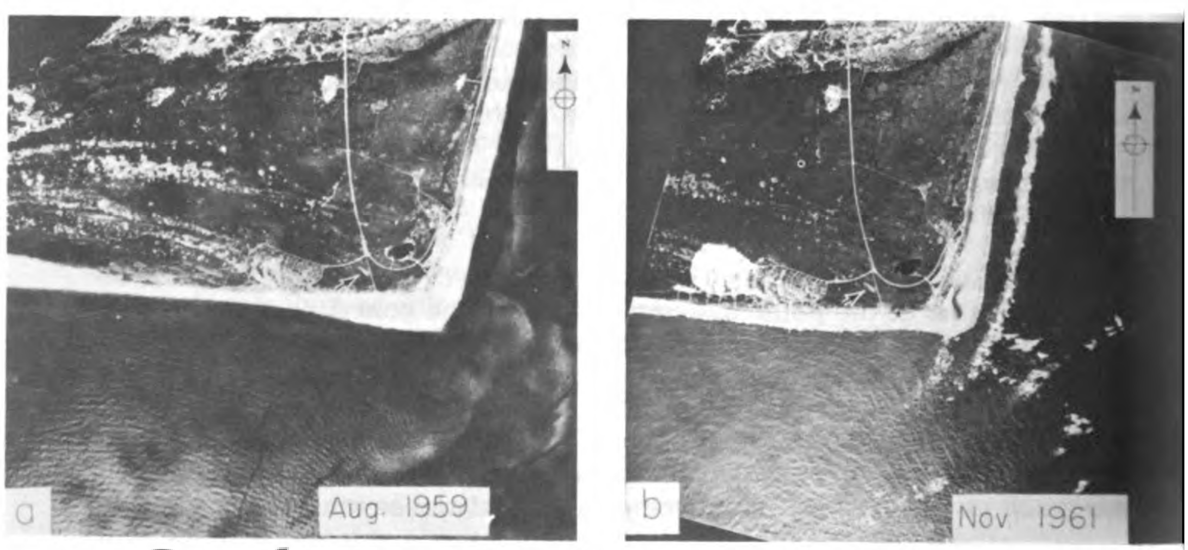


Figure 1—Cape Hatteras, 1945 to 1958.



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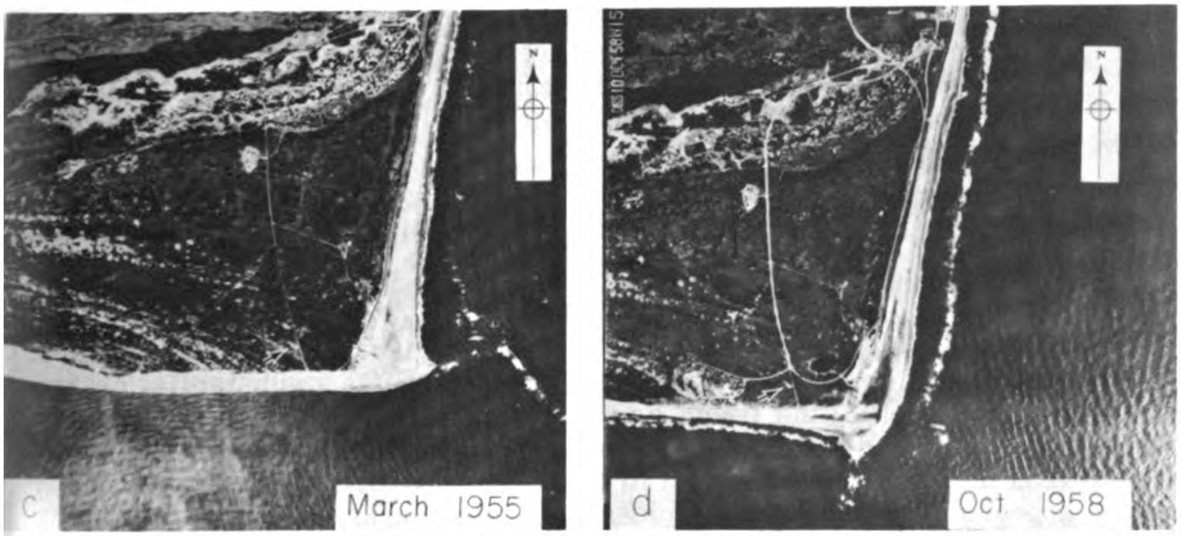
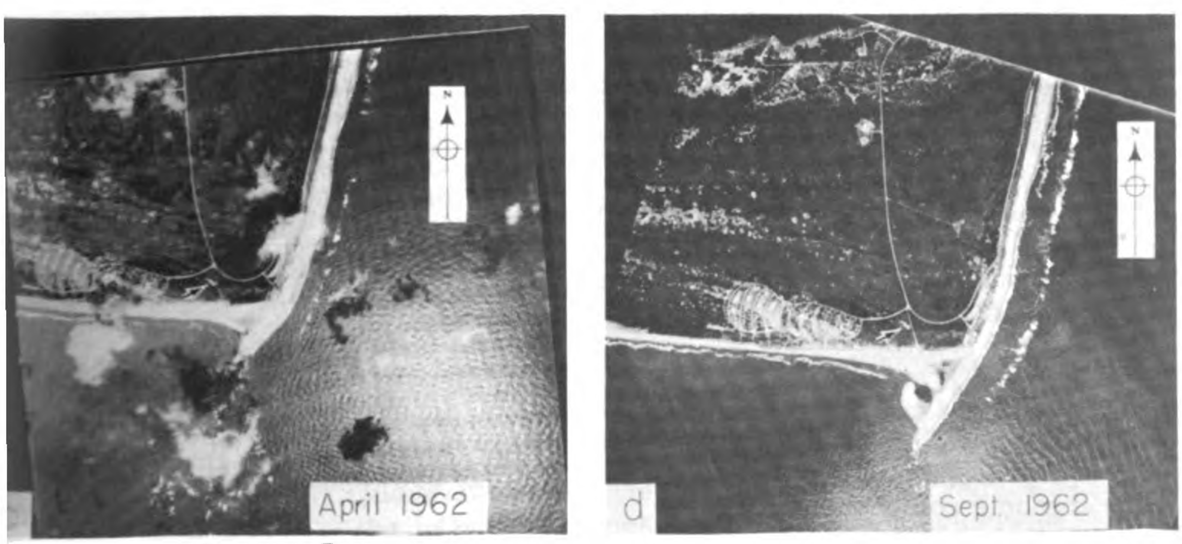


The sets of aerial photographs reproduced above and below reveal changes in topographic features which occurred at Cape Hatteras, North Carolina, over a 17-year period. The more noteworthy changes are discussed in the text.

Figure 2—Cape Hatteras, 1959 to 1962.



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different for each. This assumption is amply supported by comparative measurements of erosion which have been made on the photographs. The chief point of reference for these measurements is an enduring area of bare sand, indicated by the arrow near the tip of the cape on each photograph (Figures 1 and 2).

THE CHANGING TRENDS OF THE BEACHES

Erosion of the south beach is very impressive. At the widest part of the beach southwest of the reference point (Fig. 1a) the loss between 1945 and 1953, measured roughly at the high-water mark, amounts to 1500 feet. Comparison of these two photos reveals a substantial change in orientation of the beach as this erosion took place. Whereas formerly the trend of this beach was west-northwest to east-southeast, since 1953 the trend has been west to east. Furthermore, most of the erosion appears to be confined to a pie-shaped wedge near the point, apparently with little change occurring farther west.

Between 1953 and 1958 an additional 300-foot strip was lost. With this change, the total recession of the south beach since 1945 amounted to about 1800 feet, or three-tenths of a nautical mile. After 1958, conditions there seem to have stabilized (Fig. 2), in part, perhaps, because of the dune stabilization program of the National Park Service, or perhaps because of some shift in the wave and current regimen of the area.

Measurements in the vicinity of the parking lot about 2000 feet north of the point indicate that the east beach grew seaward a few feet between 1945 and 1958, and by 1961 had gained 300 feet over its 1945 position. In March and September 1962 it was a little narrower. In contrast to the vast changes noted for the south beach over the 17-year period, general stability apparently prevailed along the east beach.

THE "WANDERING" SPIT

A prominent and puzzling feature at Cape Hatteras is the "wandering" spit at the very tip of the Cape. The photographs taken in 1945, 1953, and 1955 (Fig. 1a, b, and c), show that this spit pointed easterly during those years. In April of 1956, the spit still had an easterly orientation, but by October it had assumed a definite southerly direction. No photographs are available for 1957. A movie film taken in January 1958 indicates a continuing, but less pronounced southerly orientation, which appeared to hold through October (Fig. 1d). A neutral situation appears to have prevailed in August 1959 (Fig. 2a), with essentially no spit at all in evidence. In December a small spit had formed which pointed southeasterly, curving slightly easterly. This orientation continued, apparently through September of 1960. Two flights were made in that month, one before and one after hurricane Donna. This storm, which was quite severe in the Hatteras area, seems not to have affected the spit in any marked way.

By November 1961 (Fig. 2b) the easterly pointing spit had been wiped out, and a trace of a southerly orientation appeared. In April (Fig. 2c) there was a well developed, southwesterly oriented spit, and in the final photograph (September, 1962), this spit had grown considerably and had become compound.

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Similar "wandering" spits occur both at Cape Lookout, 63 miles to the southwest and at Cape Fear, 88 miles farther southwest. Very noteworthy is the fact that the orientations of these spits at any given time appear to be synchronous. This determination is based on twelve observations made between 1945 and 1962 of Cape Lookout and eight observations made between 1954 and 1962 of Cape Fear. When the orientations of these capes were compared with those of Hatteras, they were found to be the same in each instance. Although these few comparisons can hardly be called conclusive, they certainly suggest that regional, rather than local factors ultimately control the orientation of the spits.

One way of delineating these factors might be to analyze daily wind and wave directions over recent years to determine their net effect on littoral drift in the vicinities of the capes. Shifts in position of the western boundary of the Gulf Stream might cause relocations of current eddies in the vicinities of the capes which would cause deposition at one time in one place and at another time elsewhere.

CHANGES IN HATTERAS INLET

Hatteras Inlet (see Figs. 3 and 4), located between Hatteras Island and Ocracoke Island, is one of the major inlets of the Outer Banks. According to available information, this passage and Ocracoke and Oregon Inlets have remained open for more than 100 years. These features are not entirely stable, however, inasmuch as they are migrating slowly, and their bars and shoals are continually shifting. One report for example, indicates that Hatteras Inlet migrated southwesterly about three-fourths of a mile between 1860 and 1915.

It is readily apparent from the photographs reproduced here that the eastern side of the inlet has not changed greatly since 1945, particularly the inner, vegetated part. The outer, lower part of the spit, which is frequently washed over by storm waves, experiences losses and gains with some consequent fluctuations in its outline, but, in general, has maintained its position throughout the interval covered by the photographs. The western side has changed markedly, however. Between 1945 and 1953 considerable material appears to have gathered at the very tip of the spit, perhaps as a result of a widening of the inlet channel which forced the shoals at the west side of the channel to coalesce with the spit. The photograph for March 1955 reveals that the part of the spit east of the Hatteras Inlet Coast Guard Station pier (indicated by the longer arrow) had been cut off from the main island and had been badly dissected. By 1959 (Fig. 4a) the pier and the entire Coast Guard installation had disappeared. The longer arrow (out in the water now) points out the approximate site of the pierhead. In the two final illustrations (Fig. 4b and c) the position of the arrowhead indicates that the beach was steadily retreating.

The shorter arrow in each of the photographs (located 4000 feet to the left of the pier site) points out a northerly oriented dune area called Styron Hills on the U.S.G.S. topographic quadrangle maps. This feature, which appears in each view except that of 1955, serves as an additional useful landmark for indicating the changes which have occurred. Between 1945 and 1953 the beach and dunes were cut back considerably.

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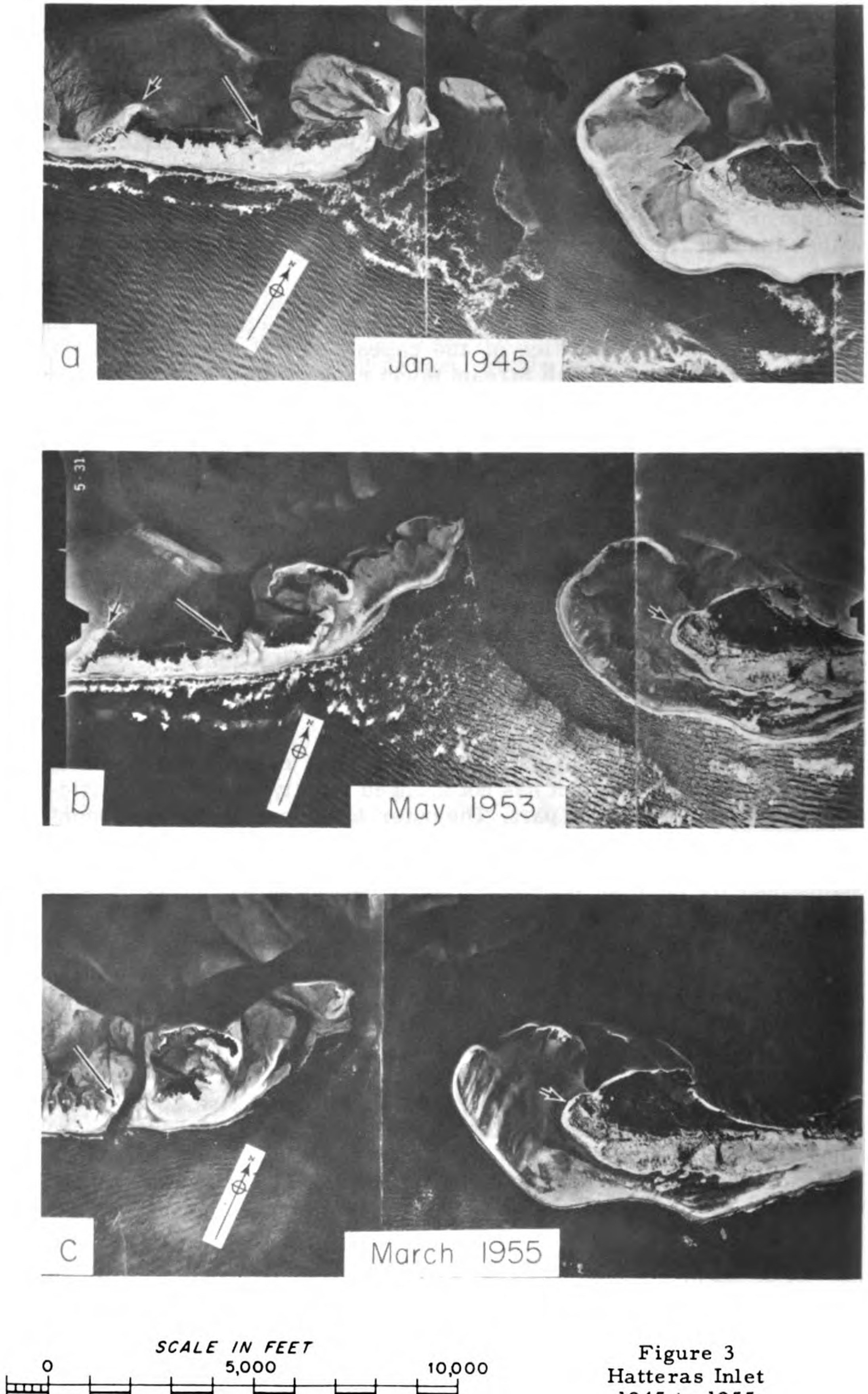

Figure 3
Hatteras Inlet
1945 to 1955

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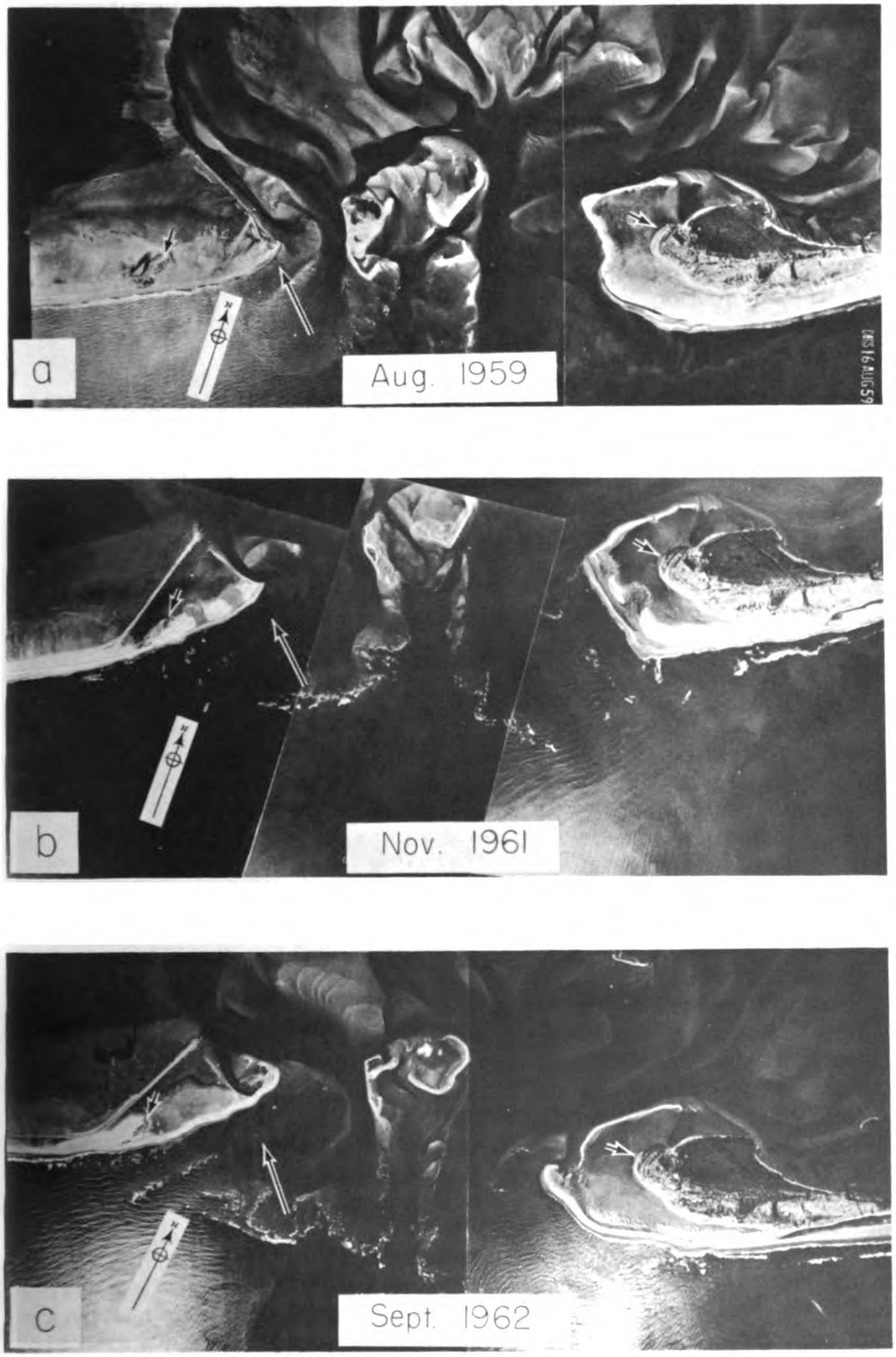

Figure 4
Hatteras Inlet
1959 to 1962

SCALE IN FEET
0 5,000 10,000

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In the August 1959 view (Fig. 4a) additional retreat may be measured. A road now appears (very faintly) running through the dunes and out to the end of the spit adjacent to the now inundated site of the Coast Guard Station. The approach to the ferry landing is seen branching to the north from this road not far from the end of the spit. By 1961 the entire road system east of Styron Hills had gone, and the ferry landing and its approach road had been relocated to the west of the hills.

Total recession of the west side of the inlet since 1945 has amounted to about 1 nautical mile. It is true that the spit did not recede continuously by simple widening of the inlet, but, rather, new subsidiary inlets have cut off sections of the spit, creating a series of islets. However, these islets are also being steadily eaten away, and a very wide inlet seems to be in process of formation.

If the inlet is still migrating southwestward, as it has been doing in the past, one should expect that material would be accumulating on the eastern side of the inlet. The final view (Fig. 4c) does indeed indicate some forward growth of the outer beach. This growth may be permanent, or, as the photographic record suggest, it may quickly disappear with the next severe storm. However, the inner part of the spit, in the vicinity indicated by the small arrow on each view, shows definite and continued accretion to the extent of about 400 feet during the interval between 1945 and 1962. Admittedly this is only a fraction of the losses sustained at the other side of the inlet, but the deposits here are higher in elevation than those of the more ephemeral outer beach, and they appear to be gradually supporting vegetation.

An interesting aspect of this forward growth on the eastern side of the inlet is the fact that it appears to be progressing in the form of a series of crescent-shaped beach ridges. In 1945 (Fig. 3a) only the vaguest indication of a ridge can be seen at the western end of the inner spit (at tip of arrowhead). But in 1953 this ridge was well defined, and it persisted in the 1955 view. By 1959 (Fig. 4a) the spit had been extended a little more, and a second ridge apparently was in the process of formation west of the first. By November 1961 this second ridge was well defined, and a third ridge, outside of the first two, had formed. This condition persisted in the final view—September 1962. The apparent lack of these features on the older part of the spit suggests that some significant change in conditions of sand deposition and beach accretion has occurred in recent years. Another investigator, David Smith of Louisiana State University, in a study sponsored by ONR, observed that a sequence of these "inlet-marginal sand ridges," as he refers to them, is normally found on the updrift side of major inlets in the Outer Banks area, but not at the more ephemeral inlets.

W.H.O.I. expects to continue making periodic photographic flights along the coast, timed, when feasible, to take place soon after severe storms. The type of photography employed will be determined by the atmospheric conditions prevailing at the time of the flight. "Verticals" are naturally best for obtaining quantitative data, when weather permits, but the lower altitude, slow-speed movies will undoubtedly continue to be important to the program, not only because they can be obtained under less favorable weather conditions, but also because of the additional areal coverage they afford, which is of decided value for the historical record.

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On the Naval Research Reserve

NRRC 1-1 Tours the USS AEOLUS

On April 1, Naval Reserve Research Company 1-1, Boston, Massachusetts, made an interesting tour of the USS AEOLUS (ARC-3). Significantly, the ship's commanding officer was associated formerly with the Research Reserve Program. This man, CDR L. P. Hoskins, USNR, was Reserve Assistant at the Office of Naval Research Branch Office, Chicago, from 1959 to 1962.

The tour of the USS AEOLUS, one of the Navy's three active cable ships, was conducted as a Naval Reserve drill. Arrangements for conducting the drill on board were made with CDR Hoskins by CAPT A. H. Healy, USNR, commanding officer of NRRC 1-1 and head of the Contract Administration Department, ONR Boston. In addition to the tour, the company members were given the command presentation in which the ship's history, mission, and capabilities were discussed.

AEOLUS Executive Officer, LCDR D. B. Leach, USN, describes some of his ship's cable machinery to CAPT A. H. Healy and CDR Thomas B. Dowd as CDR Hoskins (far left) looks on.

New Research Reserve Company

With the establishment of a new Research Reserve company at Santa Ana, California, the Eleventh Naval District has expanded its number of such companies to 12. The new unit, Naval Reserve Research Company 11-12, was activated by the Commandant, Eleventh Naval District, effective February 1, 1963.

Under the command of LCDR John N. Echternach, USNR, a qualified group of Research Reserve officers will hold biweekly meetings at the Naval Reserve Training Center, Santa Ana, California, on the first and third Thursdays of the month.

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During the Visit to Argonne

During the Symposium on Nuclear Capability held recently at the Argonne National Laboratory, Lamont, Illinois, the 138 officers who took part toured some of the laboratory facilities (NavResRev, May 1963). One of the scenes photographed during the tour—received too late to include with the May account of the symposium—is reproduced below.

Members of NRRC 9-15 Midland, Michigan study an 80,000 volt linear accelerator at the Argonne National Laboratory.

Inter-Service Tour

Twelve officers from Research Reserve Companies 6-3, Oak Ridge, Tennessee, and 6-17, Huntsville, Alabama, performed three days of group active duty for training (without pay) with the 9308th Air Recovery Squadron, commanded by MAJ Jack K. Westbrook, USAFR, during the weekend of April 19-21.

Air Recovery squadrons have been established recently to provide, in emergencies, necessary services to aircraft which cannot return to their home base, so that they may continue their mission. To train the squadrons for this work, surprise exercises are conducted which pose problems that might arise during a real emergency.

Such an exercise was witnessed by the Research Reservists. A C-123 cargo aircraft, the first of a hypothetical group of 40 such planes, had encountered rough weather and needed to off-load 30 paratroopers, some injured, and to refuel for a long flight. As far as practical, recovery procedures, such as survey for radioactive contamination and washdown of the plane, were carried out by squadron personnel. Concurrently, staff personnel were solving the logistic and other problems posed by the exercise. The exercise was culminated by a critique, wherein the problem and its solution were reviewed, to assess the readiness and to broaden the capability of the squadron. A tour of the facilities of the McGhee Tyson Air Force Base completed the weekend training.

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The Research Reservists who participated in this weekend training benefited from observation of the Air Force training procedures and were made aware of a vital link in the national defense structure. It is felt that other Research Reserve companies will find similar inter-service tours rewarding.

Seminar Includes Bomb Shelter Test

Without advance warning a group of 34 Naval Reserve officers who reported for the Life Sciences Seminar at Bethesda, Maryland, were taken into the experimental protective shelter at the National Naval Medical Center on May 13 to begin an unprecedented study in shelter habitability. The officers entered the shelter on the opening day of the seminar for a lecture on previous fallout shelter tests which had been scheduled as part of the seminar program. During this lecture, the nature and purpose of the proposed test was revealed to the officers. These men were then asked to volunteer as a group to remain in the shelter for an unspecified period of time. All accepted the challenge!

The seminar was organized and conducted by members of Naval Reserve Research Company 5-10, Bethesda, Maryland. Serving as Chairman was CAPT George Z. Williams, USNR, and assisting him were the following members of the company: CAPT Urner Liddel, CDR Richard Trumbull, LT William V. A. Abt, and LT Sherman Ross. Two of these members, CAPT Williams and CDR Trumbull, were among the 34 officers who participated in the shelter test. The trial was a joint project of the Naval Medical Research Institute and the Office of Naval Research as part of a program to gain knowledge of the psychological response and physiological stresses of men of various ages and backgrounds while living in the shelter for an unknown period of time.

Previous trials of the fallout shelter have been conducted, but in each case the participants knew in advance that they would be confined to the shelter. The most recent experiment was the first one in which the participants did not have advance warning or were given an opportunity for preparation before entering the shelter. Data were collected which are expected to be of great value to those concerned with planning for protection in a shelter.

The 34 officers remained in the shelter from Monday, May 13, to Friday, May 17, at 1300. During this time, a two-way closed-circuit television system was in operation, primarily to give the men lectures on fallout shelters. This circuit was also used periodically to observe the behavior of the reservists. The men slept in their clothes, and they lived on special rations of biscuits and soup. Because only a limited amount of water was available, they were not able to shave or use water for washing. Small packets containing moistened paper washcloths were available.

As part of the simulation of the use of the shelter under real conditions, a radioactive pellet was lowered into a tube just outside the shelter. The men were told they could leave when the radioactivity dropped

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to a safe level. Beginning on the second day, two men dressed in special antifallout suits emerged to measure the amount of "radioactivity" outside the shelter. Using laws of radioactive decay, they were then able to calculate the date when they could expect to be released.

On Friday, May 17, RADM L. D. Coates, USN, Chief of Naval Research, entered the shelter to thank the men personally for their cooperation and to present them with special certificates of merit. After debriefing, the men were returned to their hotels for a well earned weekend of leisure—this time of their own choosing.

On the Monday of the second week of the seminar, the program proceeded in the normal manner. Presentations and group discussions concerned with fallout protection were carried out by authorities from NMRI, National Science Foundation, Office of Civil Defense, and the Bureau of Medicine and Surgery. The Naval Reserve officers who participated in the shelter study for the four day period and earned the certificate of merit presented by RADM L. D. Coates, USN, were as follows:

CDR Audra E. Bell, NRRC 9-7, Lafayette, Indiana
LCDR Raymond H. Blackmore, NRRC 5-5, Richmond, Va.
LT Filibert R. Boston, NRRC 9-3, Ann Arbor, Mich.
LCDR Frederick O. Briggson, NRRC 9-3, Ann Arbor, Mich.
LT Robert H. Brownson, NRRC 5-5, Richmond, Va.
CDR Jay H. Brunner, NRRC 9-16, East Lansing, Mich.
LT Paul E. Caplan, NRRC 11-2, Pasadena, Calif.
CDR Walter M. Carleton, NRRC 5-10, Bethesda, Md.
CAPT Clement H. Donovan, NRRC 6-4, Gainesville, Fla.
LCDR Merle A. Engeset, NRRC 9-6, Minneapolis, Minn.
LCDR Leroy E. Everson, NRRC 9-5, Ames, Iowa
LCDR Robert B. Finley, Jr., NRRC 9-17, Boulder, Colo.
LT Stewart H. Fowler, NRRC 8-2, Baton Rouge, La.
LCDR Joseph H. Graham, NRRC 4-4, University Park, Pa.
LCDR James C. Hall, NRRC 5-5, Richmond, Va.
LT William J. Hausler, Jr., NRRC 9-19, Iowa City, Iowa
CAPT Donald T. Hawley, NRRC 6-8, Orlando, Fla.
CDR Charles W. Hawken, NRRC 9-8, St. Louis, Mo.
LCDR Robert C. Lommasson, NRRC 9-22, Lincoln, Nebr.
CDR Keith H. Morgan, NRRC 8-1, New Orleans, La.
CDR William D. Murray, NRRC 12-4, Fresno, Calif.
CDR Gordon L. Nelson, NRRC 8-13, Stillwater, Okla.
LCDR Roger E. Oesterreich, NRRC 9-1, Chicago, Ill.
LCDR Clyde R. Richards, NRRC 5-10, Bethesda, Md.
LCDR Eli A. Rubinstein, NRRC 5-10, Bethesda, Md.
LCDR Herschel L. Smith, Jr., NRRC 5-9, Washington, D. C.
LT Andrew A. Titcomb, NRRC 1-7, Hanover, N. H.
CDR Richard Trumbull, NRRC 5-10, Bethesda, Md.
LCDR John J. Walsh, Jr., NRRC 1-2, Providence, R. I.
LTJG Laurence P. Watko, NRRC 9-5, Ames, Iowa
LT Gene H. Wegner, NRRC 8-8, Bartlesville, Okla.
LCDR Alfred I. Weinstein, NRRC 11-9, Azusa, Calif.
CAPT George A. Williams, NRRC 5-10, Bethesda, Md.
LT Kennedy L. Wilson, NRRC 5-8, Washington, D. C.

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URPRISE SESSION IN A FALLOUT HELTER. See front cover (inside) nd pages 27 and 28.

With slide rule and a knowledge of the laws of radioactive decay, reservists calculate when the group can leave the shelter.

LCDR Raymond H. Blackmore indicates on a wall chart the amount of food and water he has consumed.

helter inmates erve themselves meal—a special ation of biscuits nd soup.

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IN THIS ISSUE

NAVAL RESEARCH REVIEWS publishes highlights of research conducted by Navy laboratories and contractors and describes important Naval experimental facilities. Manuscripts submitted for publication, correspondence concerning prospective articles, and changes of address, should be directed to Code 740, Office of Naval Research, Washington 25, D. C. The magazine is listed for sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Subscription price: $1.50 per year in the U. S. and Canada; $2.00 per year, foreign; $0.15 per individual copy. The issuance of this periodical approved in accordance with Dept. of the Navy publications and printing regulations.

EDITORS. A. T. Drury and Richard D. Olson

A skeleton head, simulating the head of a living person, is held rigidly in position for operation by ultrasonic radiation. See article beginning on page 1.

NAVEXOS P-510

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